

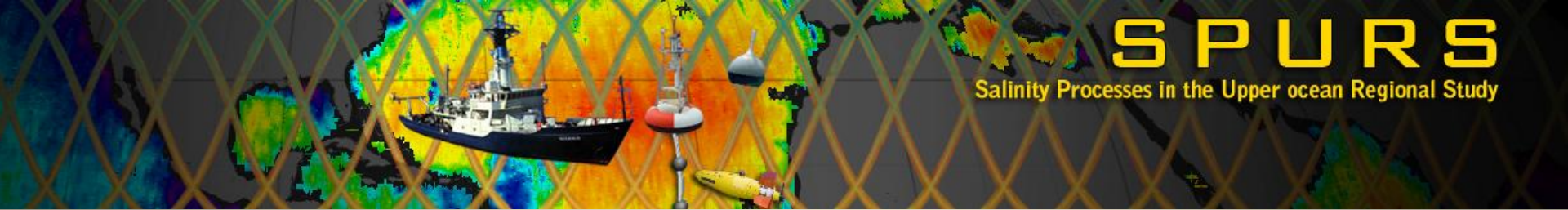


“SPURS” in the North Atlantic Salinity Maximum

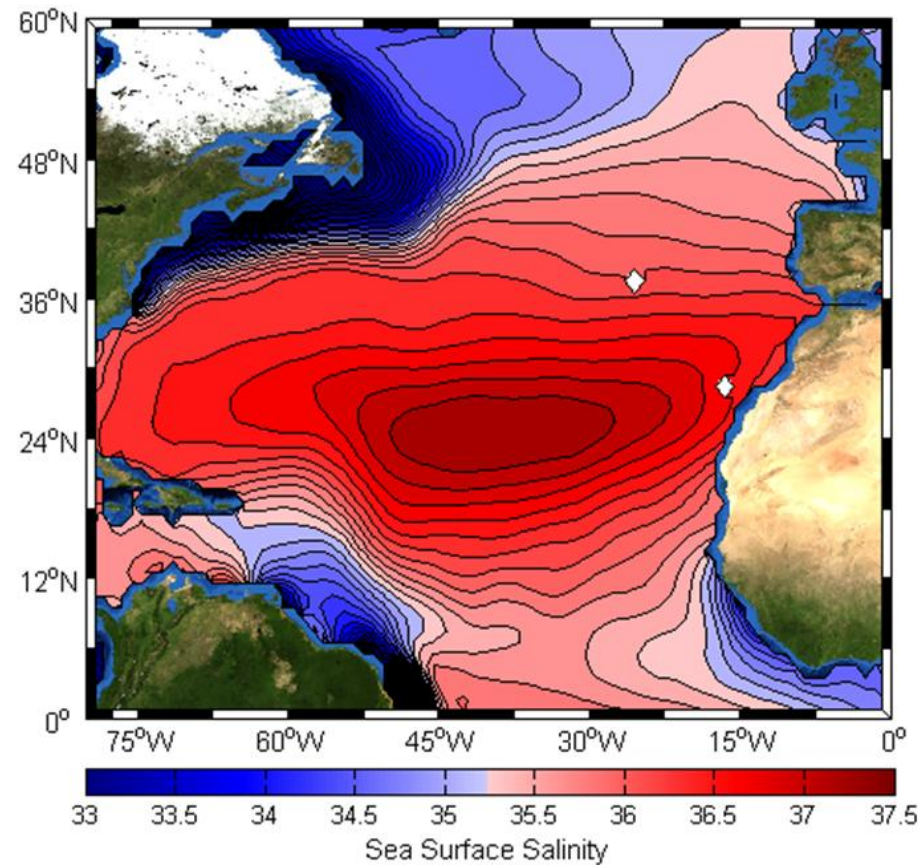
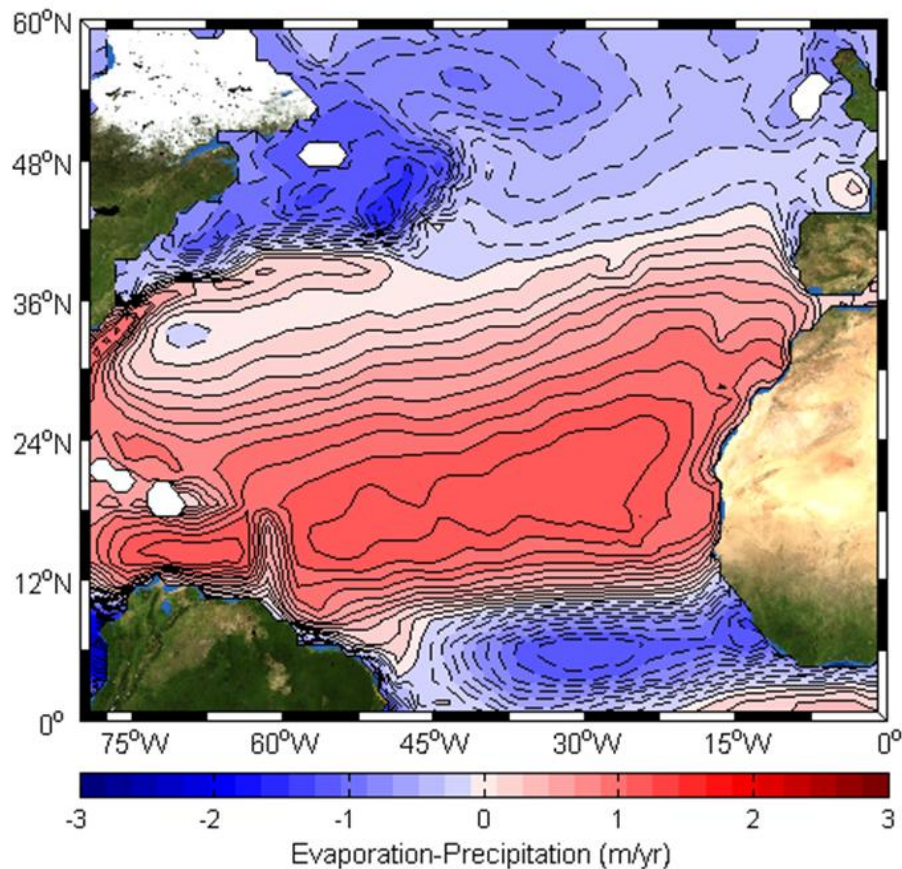
R. Schmitt

Woods Hole Oceanographic Institution

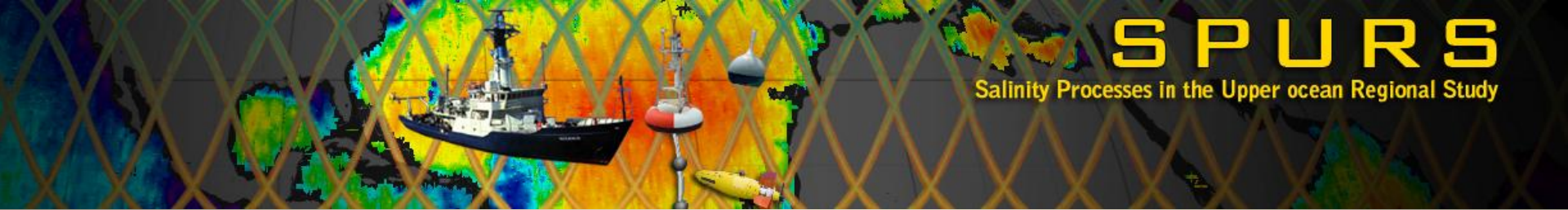




N. Atlantic evaporation-precipitation and salinity are highly correlated.



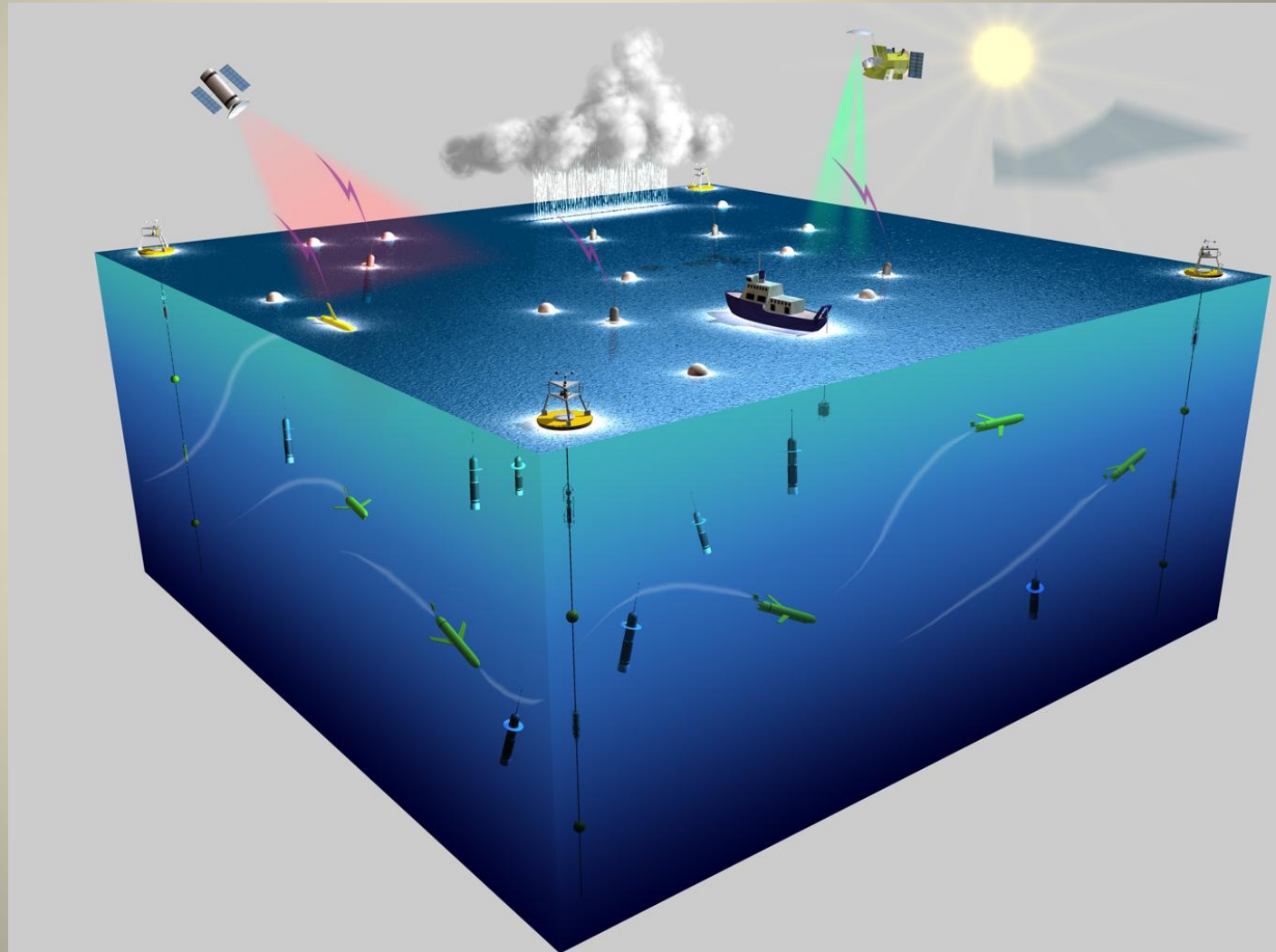
Note: the E-P zero line is close to vegetation/dry land boundary in Africa



- Multi-agency (NASA, NOAA, NSF)
- Multi-national (US, Spain, France, Ireland)
- Designed to exploit new autonomous technology (Floats, gliders, wavegliders, drifters etc.)
- Linked to but not dependent on Aquarius and SMOS salinity satellites
- Cruises:
 - French -Thalassa 8/16/12 – 9/13/12, Canaries - Azores
 - US - Knorr 9/6/12-10/9/12, Woods Hole – Azores (asset deployment)
 - US - Endeavor 3/15/13 -4/15/13, Narragansett – Narragansett (asset service)
 - Spanish - Sarmiento de Gamboa 3/16/13-4/13/13, Canaries - Azores
 - US - Endeavor 9/19/13-10/16/13, Azores – Narragansett (asset recovery)

Challenge: Integrating a diverse set of measurements

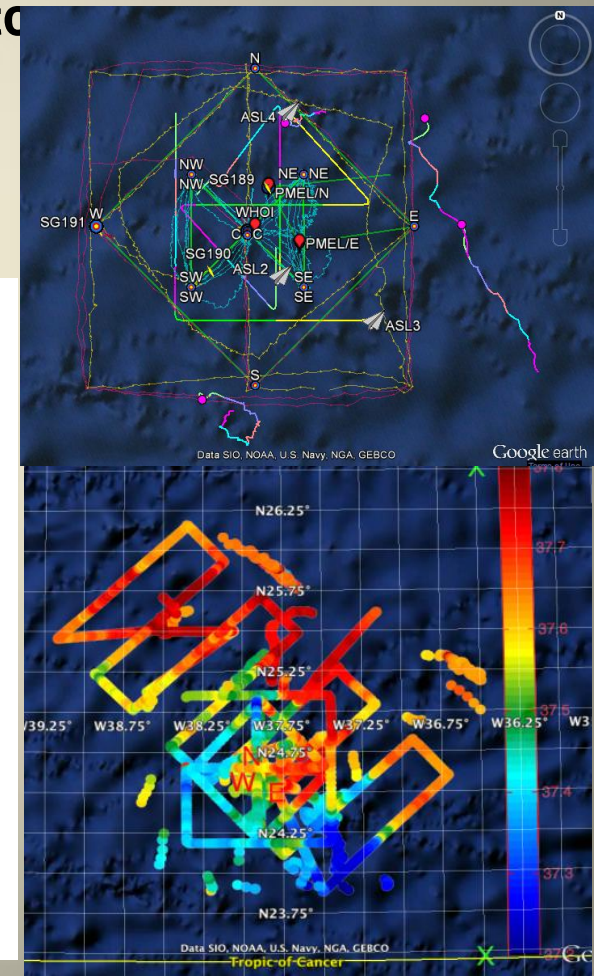
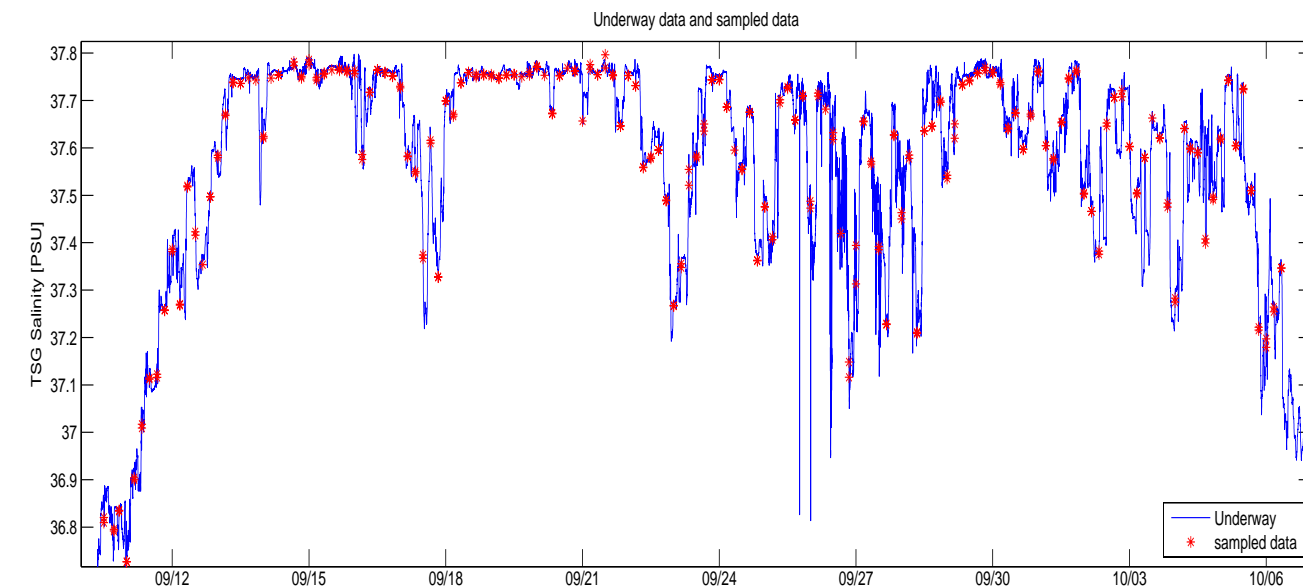
- Floats
- Gliders
- Drifters
- Moorings
- Ships
- AUVs
- Satellites
- CTD & Micro-structure profiling





Sept.-Oct. cruise of R/V Knorr

- All assets deployed successfully: moorings, gliders, floats, drifters, Wave Gliders, mixed layer float, microstructure profiler, etc
- Salinity max surveyed and found to have record high salinity ~37.8

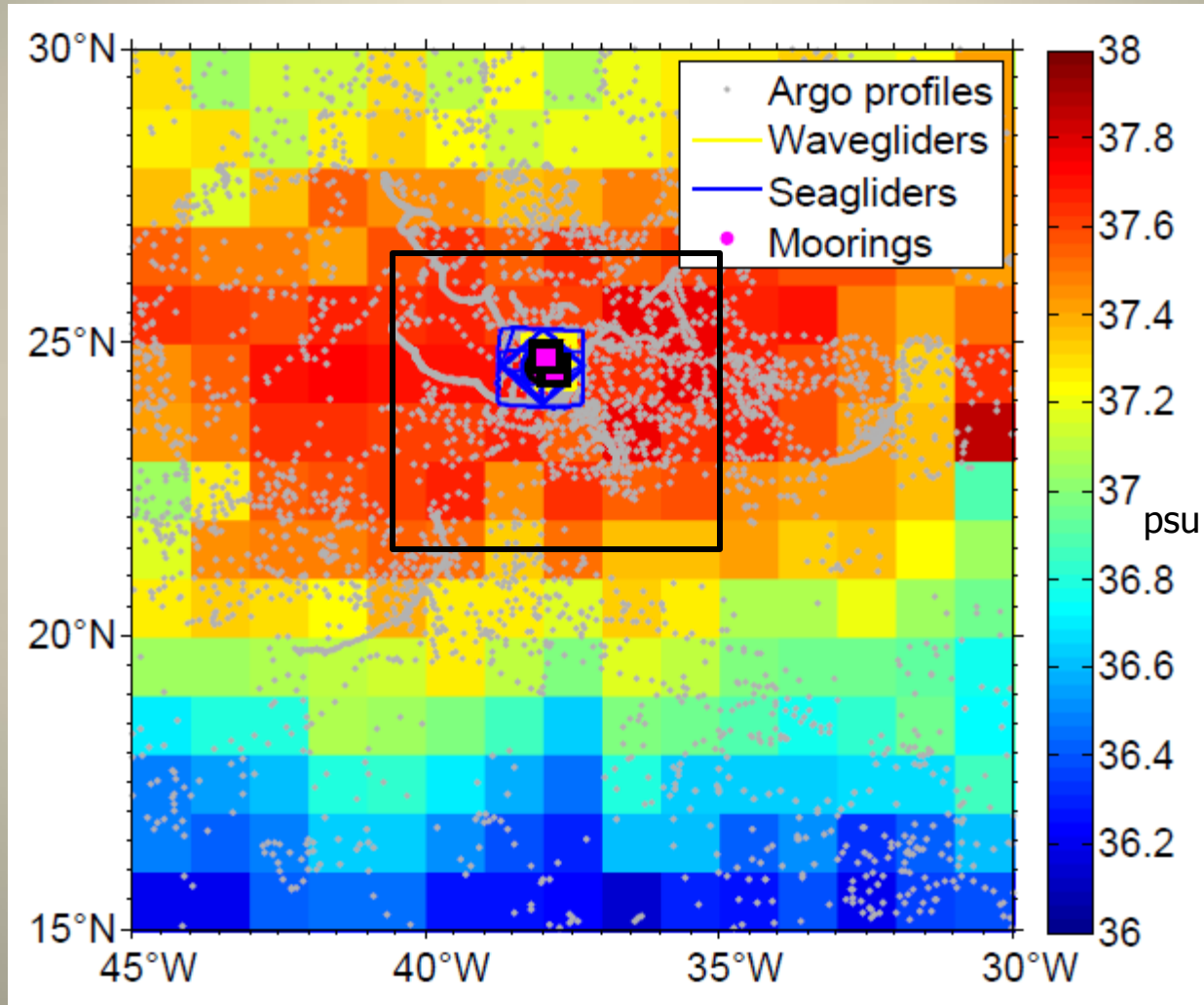


Two Approaches:

- 1. Salinity budget at the central mooring on short time-scales (T. Farrar)
- 2. Average “isohaline” budget on long time-scales (R. Schmitt)

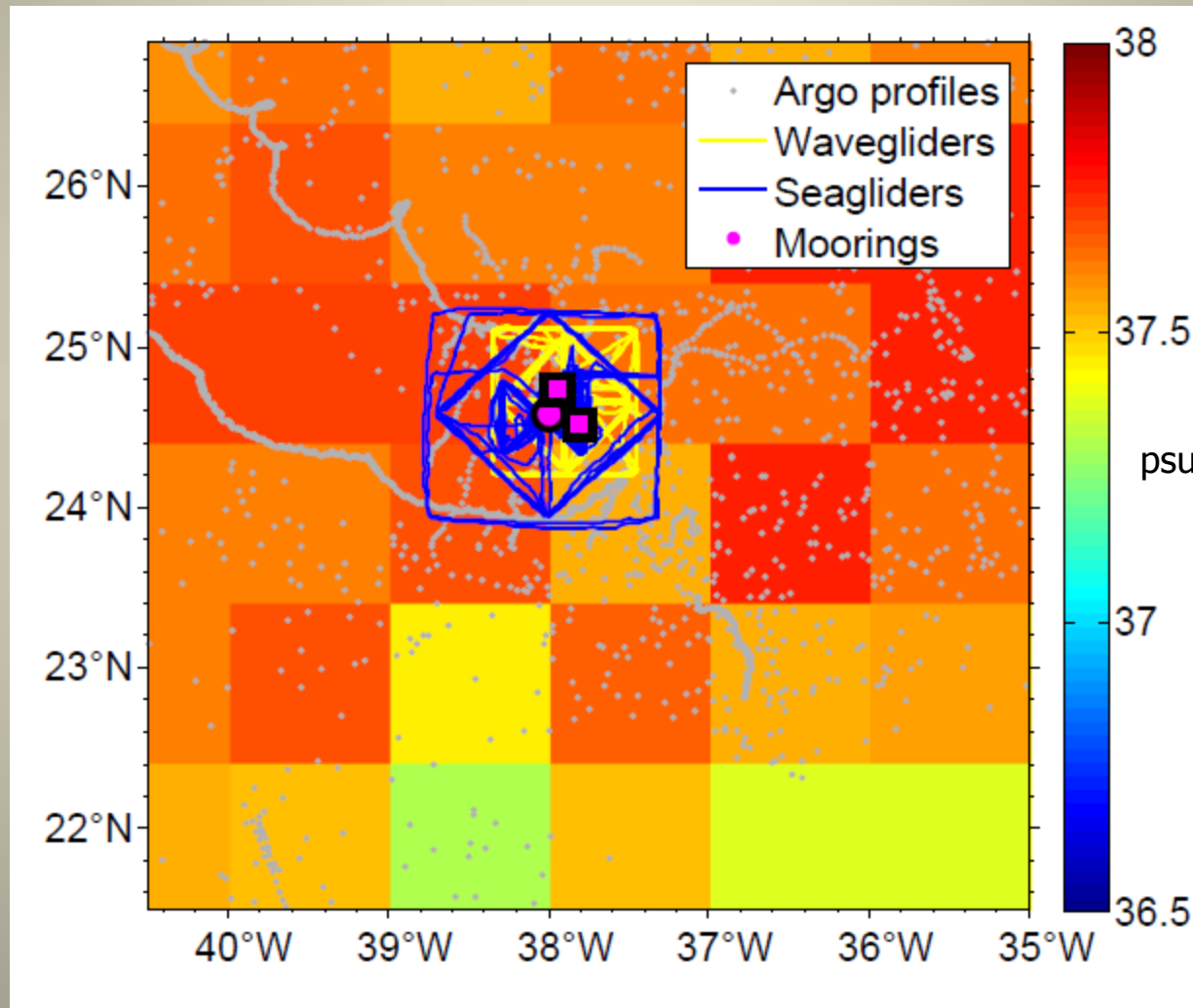
The SPURS “large box” (Tom Farrar)

Aquarius salinity, March 2012



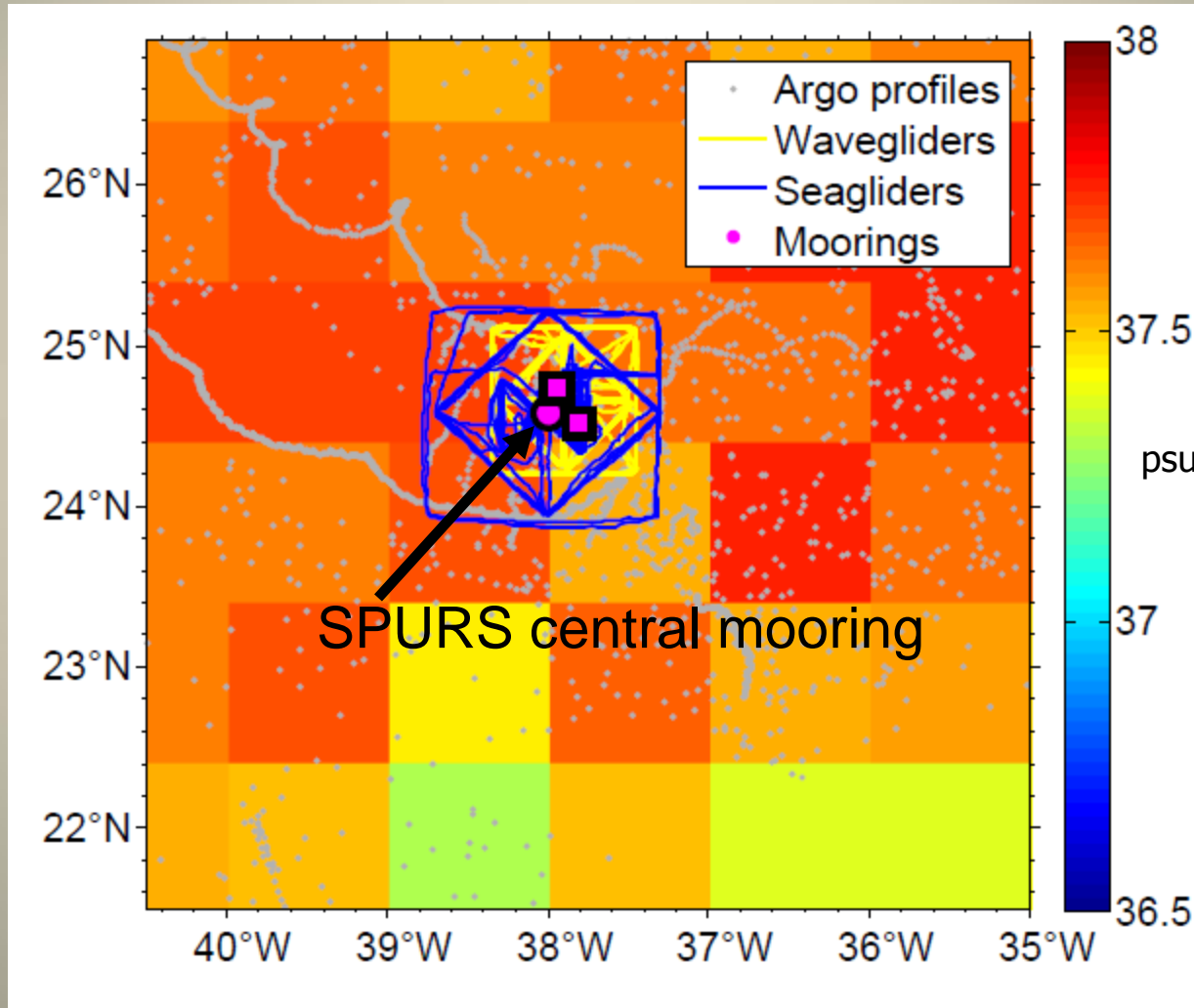
The SPURS “small box”

Aquarius salinity, March 2012



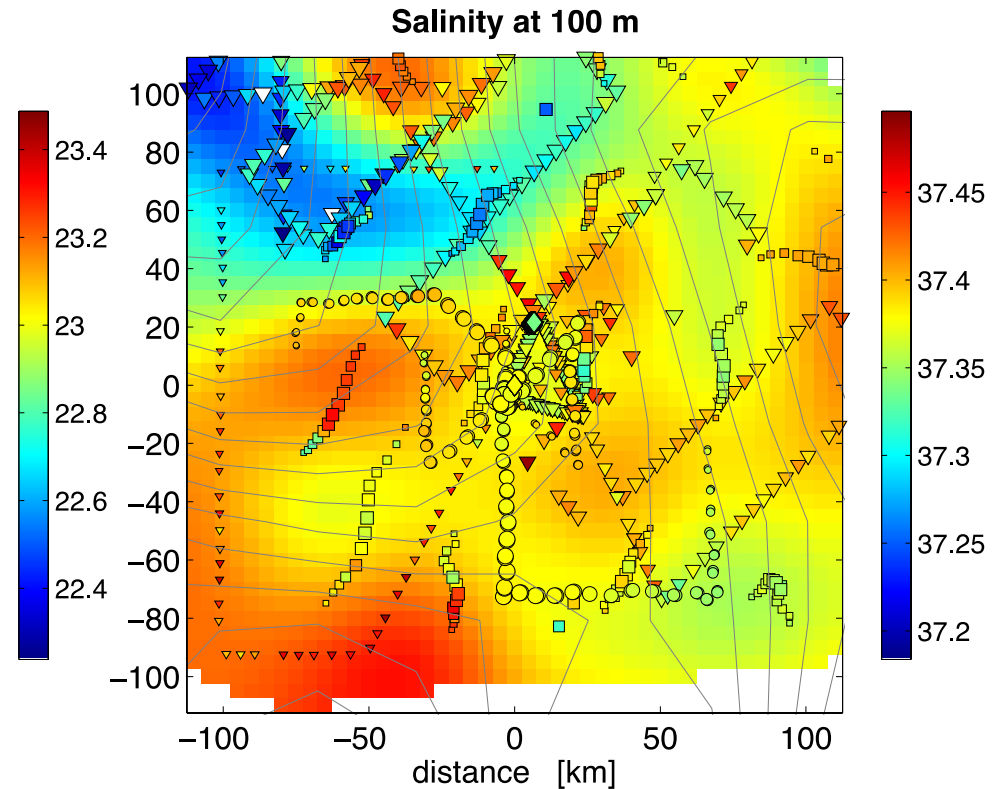
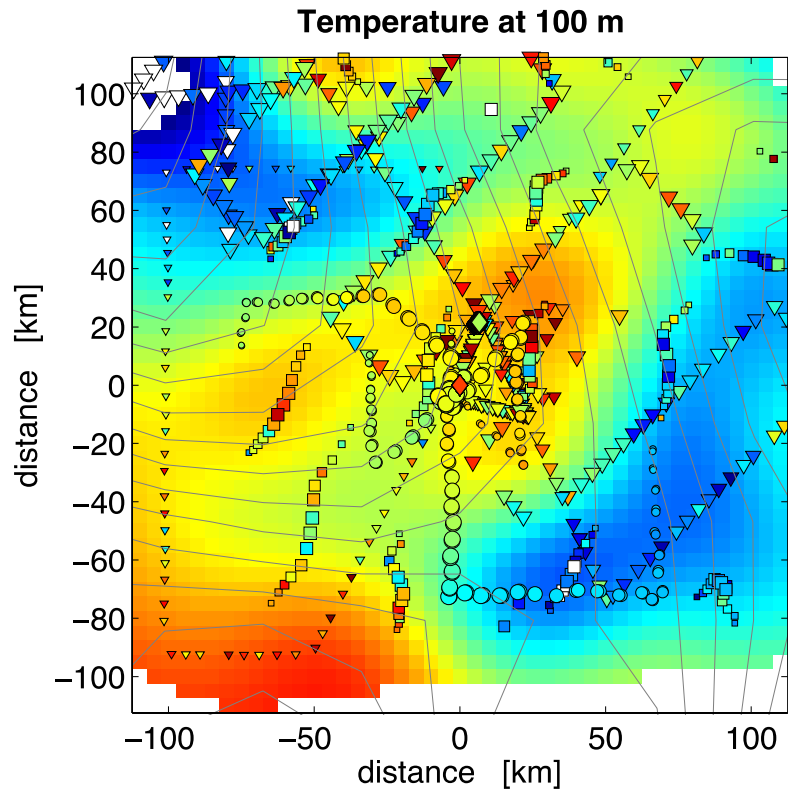
The SPURS "small box"

Aquarius salinity, March 2012



Gradient estimates, objective maps

01 Oct 2012



Decorrelation scales: 40 km and 5 days

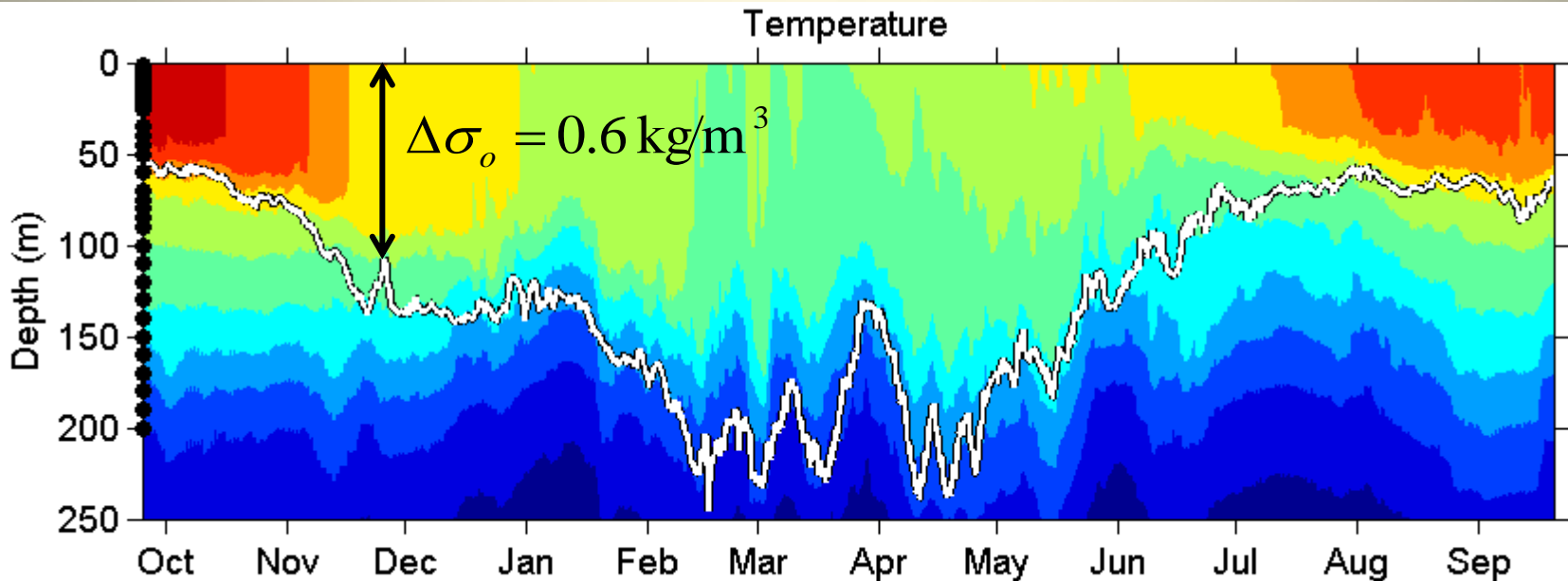
- ◆ Moorings
- Seagliders
- Argo floats
- ▽ UCTD

Note: Size of data marker is scaled by when it was collected relative to the central time.

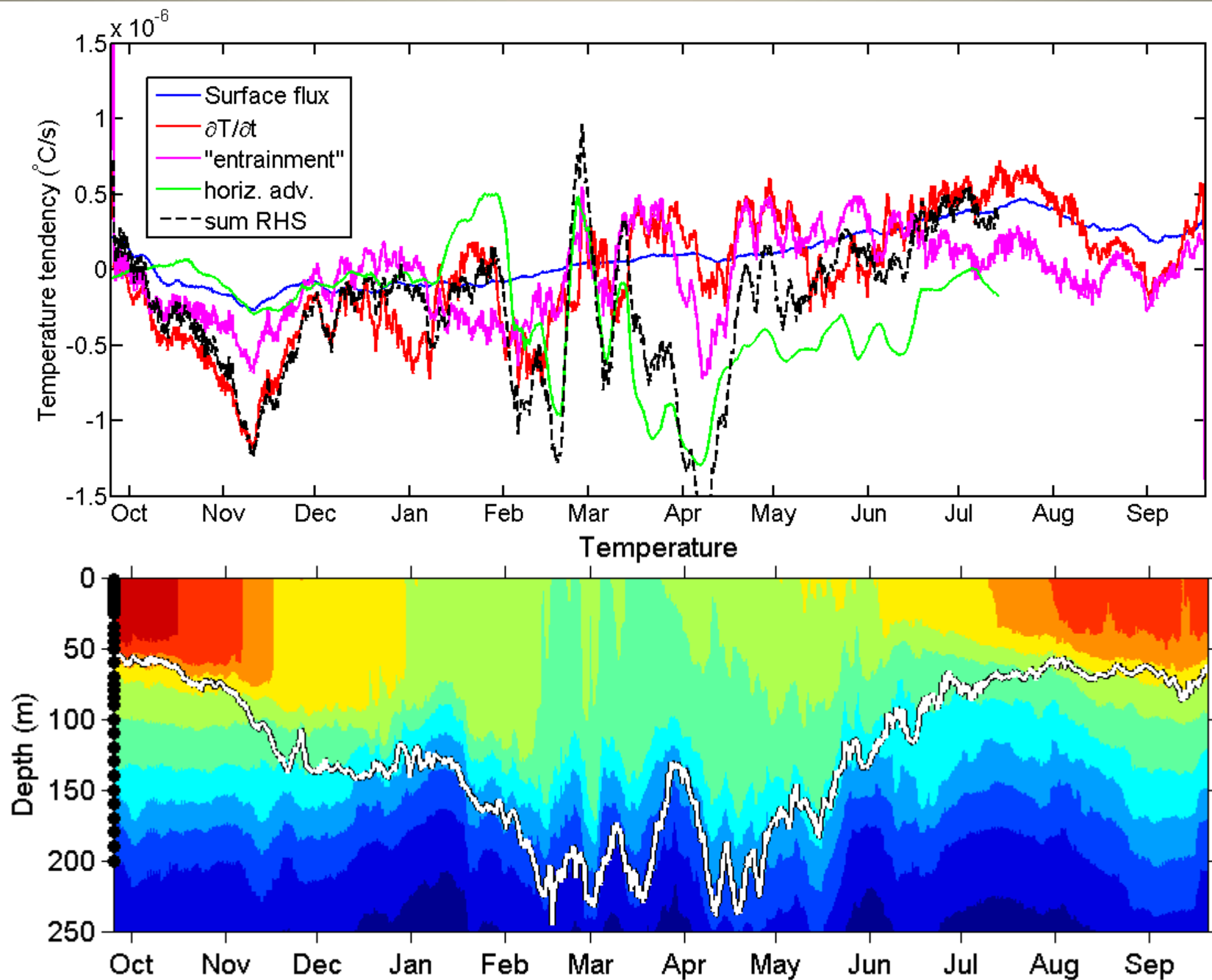
Preliminary mixed-layer temperature balance:

Evaluated for 3-week running average:

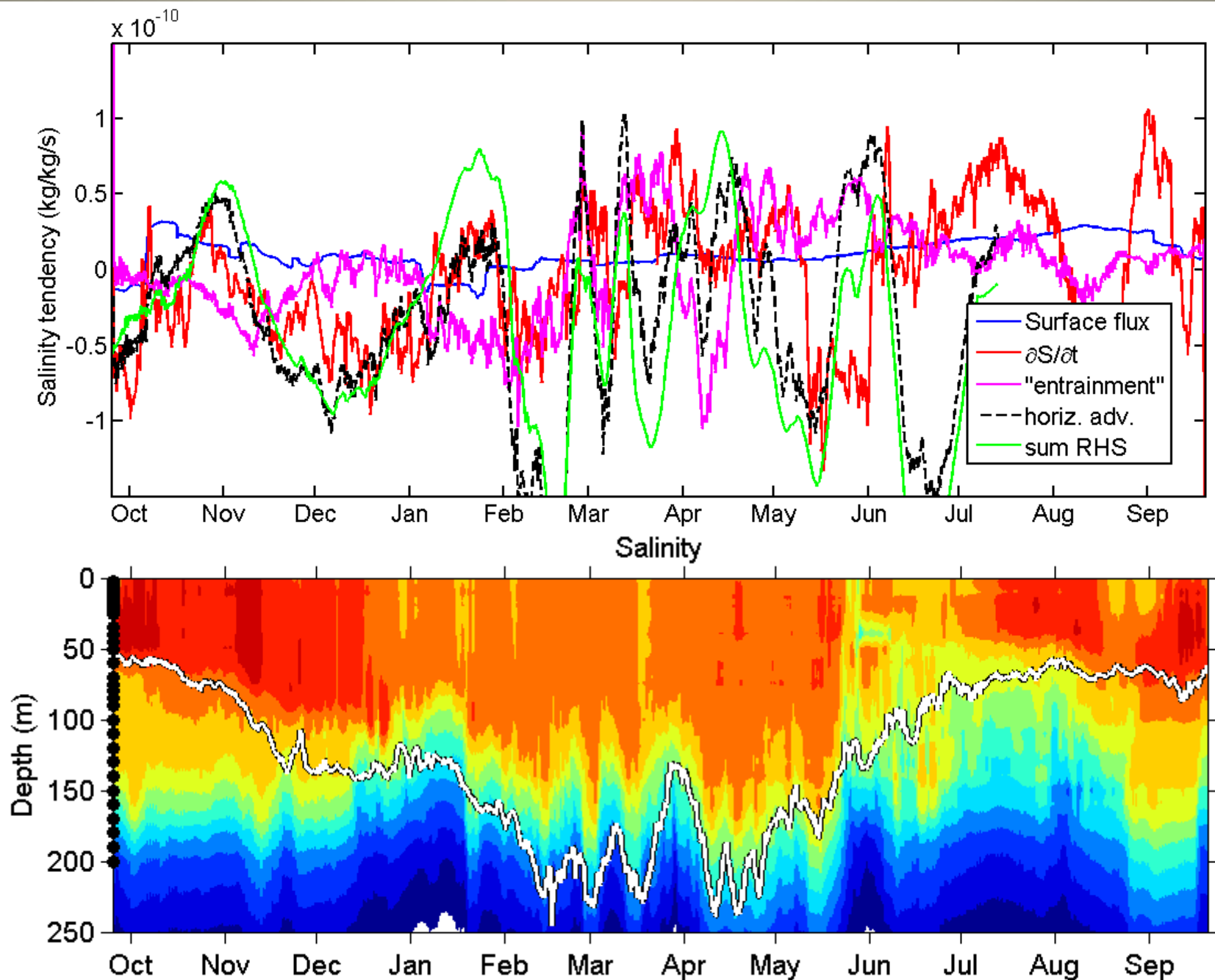
$$\frac{\partial \bar{T}}{\partial t} = -\bar{\mathbf{u}} \cdot \nabla \bar{T} + \hat{T}_{-h} \left(\frac{\partial h}{\partial t} + w_{-h} + \mathbf{u}_{-h} \cdot \nabla h \right) - \frac{Q_{-h}}{\rho c_p h} + \frac{Q_o}{\rho c_p h} - \frac{1}{h} \nabla \cdot \int_{-h}^0 \hat{\mathbf{u}} \hat{T} dz$$



Preliminary mixed-layer temperature balance:



Preliminary mixed-layer salinity balance:



Discussion of this preliminary budget:

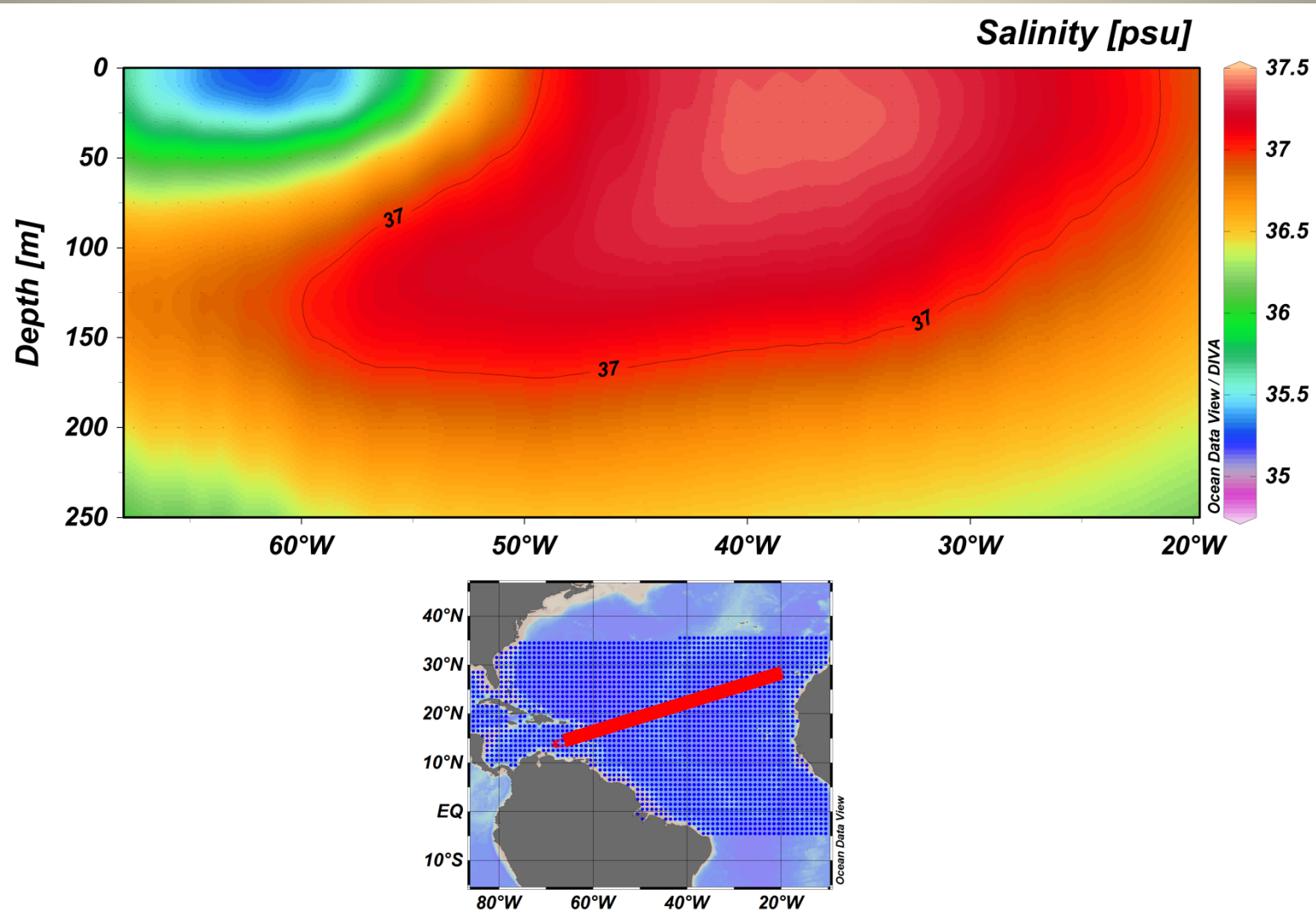
- (1) The mixed-layer temperature tendency appears to be roughly balanced by the sum of surface heat flux and mixed-layer “entrainment” terms
- (2) The mixed-layer salinity balance appears to be far from 1D on the 3-week timescales examined here
- (3) This difference is not too surprising because horizontal gradients of SSS are relatively strong. Surface heat fluxes will tend to damp SST anomalies, while surface freshwater fluxes are essentially independent of SSS.
- (4) The relative importance of terms in the budget equations will be different at different spatial and temporal scales— a larger goal of SPURS is to improve understanding of the various physical phenomena setting the mean and variability of SSS in the region.

Alternative Approach: **An “isohaline” control volume**

The idea goes back to Niiler and Stevenson (1982), “The heat budget of tropical ocean warm-water pools”, *J. Mar. Res.*, 40, 465–480.

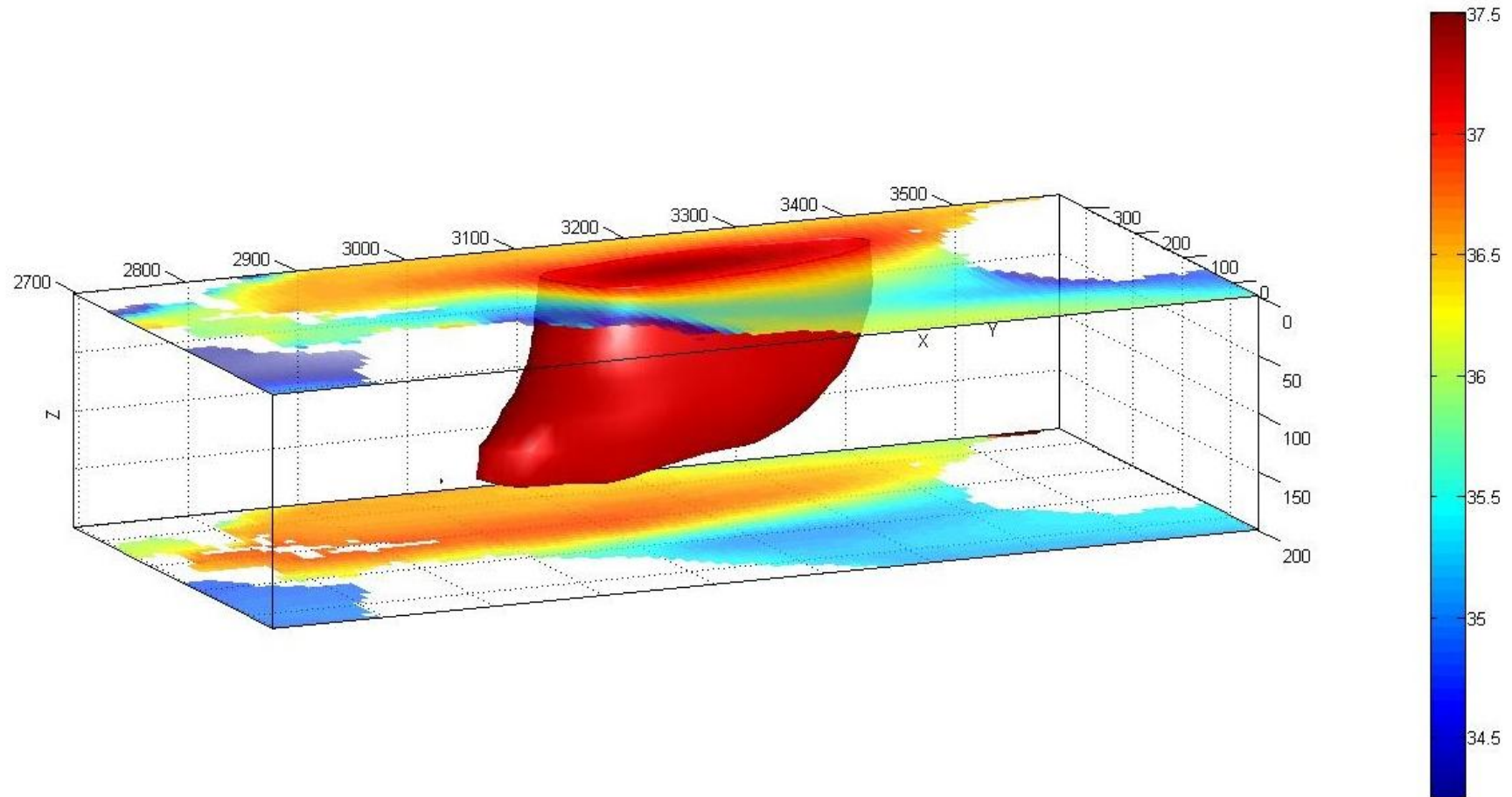
Define a control volume by an isohaline, then the mean advective terms across this surface all have the same salinity and the balanced dynamical flows can be dropped from the equations (Ekman and Sverdrup circulations). Only the net water loss due to Evaporation minus Precipitation (E-P) counts in the mean advective salt balance. This must be compensated for by vertical and lateral mixing processes.

Vertical Structure of “Subtropical Underwater”

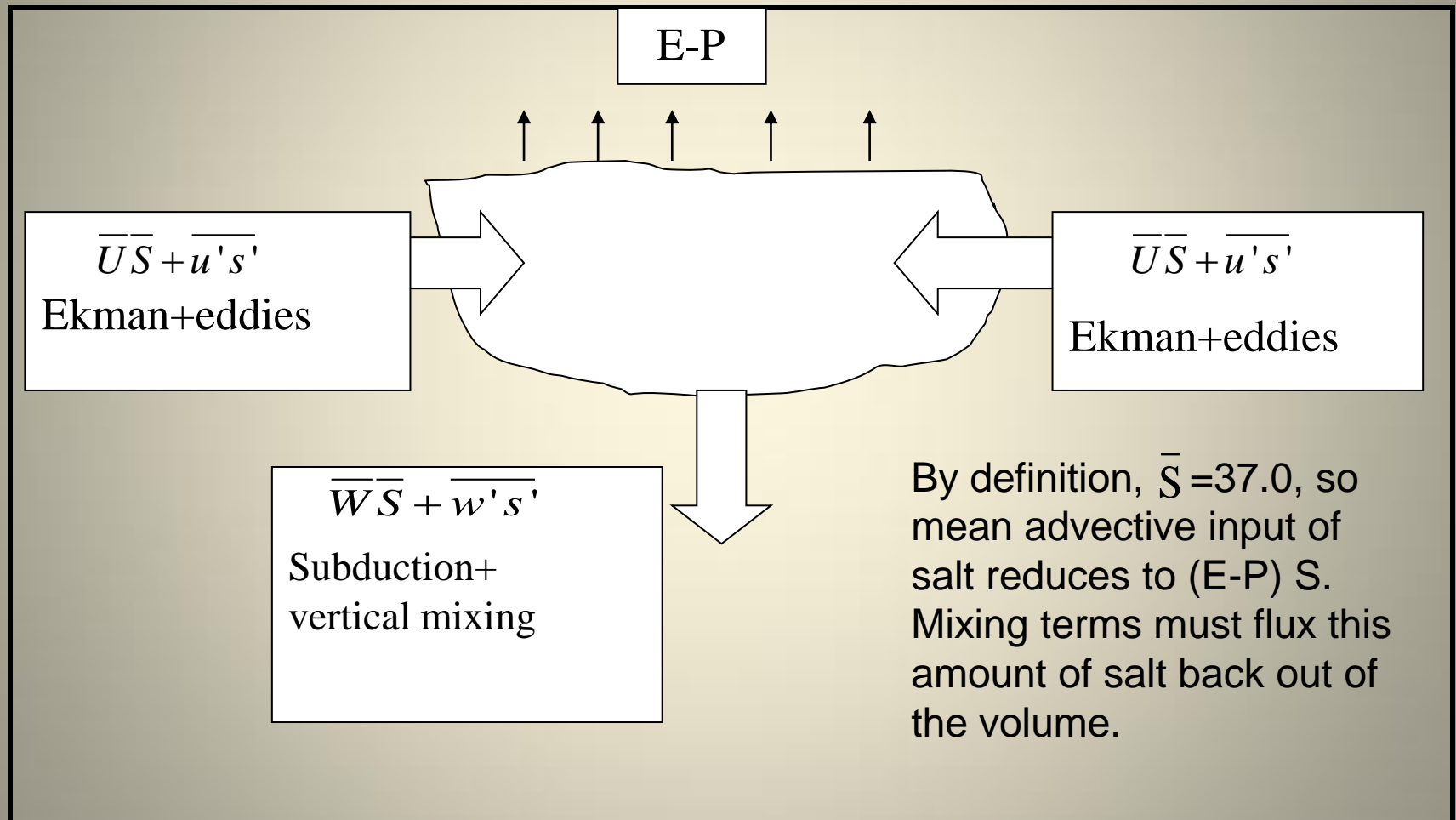


3-D Shape of the 37.0 Isohaline

Salinity Maximum Characteristics



Salt Fluxes

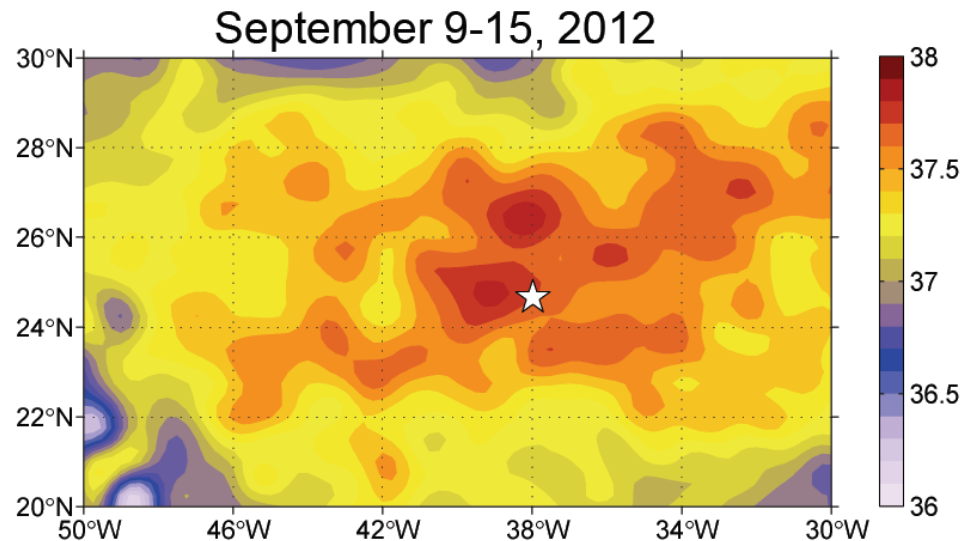
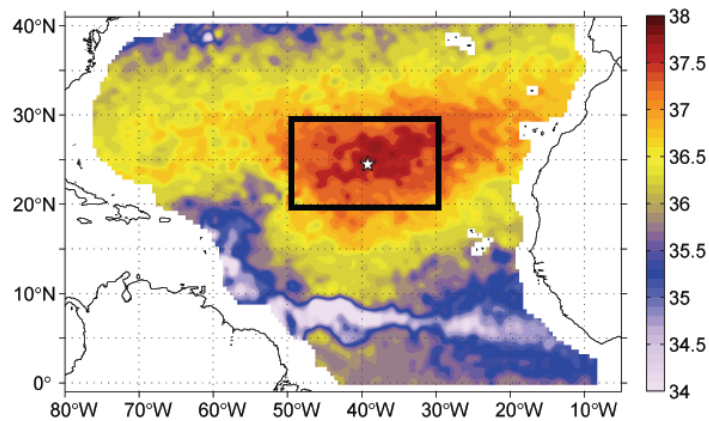


Motivation

Eddy Activity clearly seen in SSS field

International Pacific Research Center, SOEST, University of Hawaii

Aquarius OI SSS for SPURS



SPURS Meeting, Miami FL, 16-18 January 2013

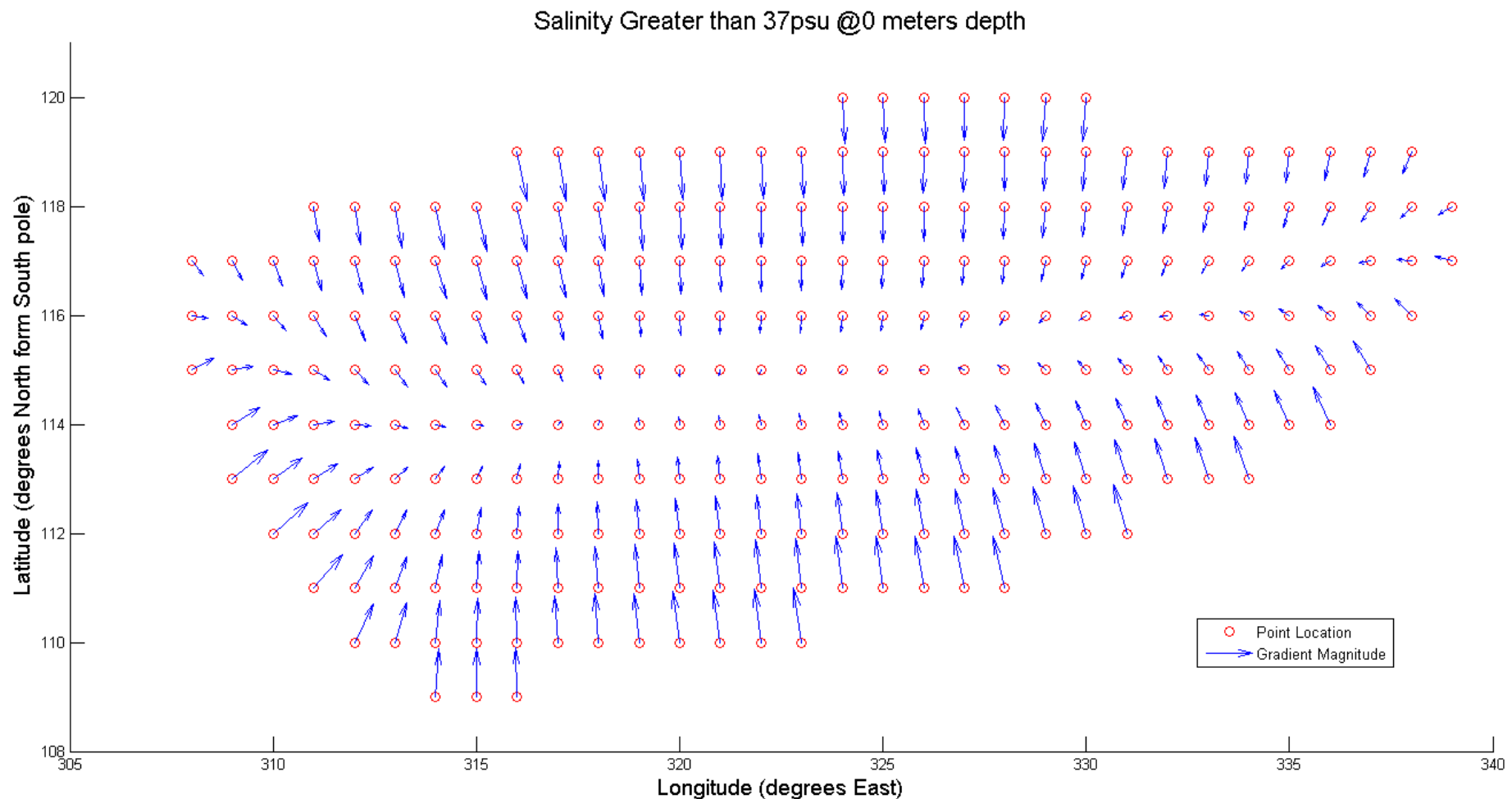
Data sources

- Use World Ocean Atlas 2009
- Define volume by $S > 37.0$
- Surface Area = $2.9 \times 10^6 \text{ km}^2$
- Net water loss from E-P = 0.11 Sv

(Schanze, Schmitt and Yu, 2010)

- Net surface salt flux = 3.9 psu-Sv

Calculation of Ring Areas and Gradients



Diffusivity Calculations

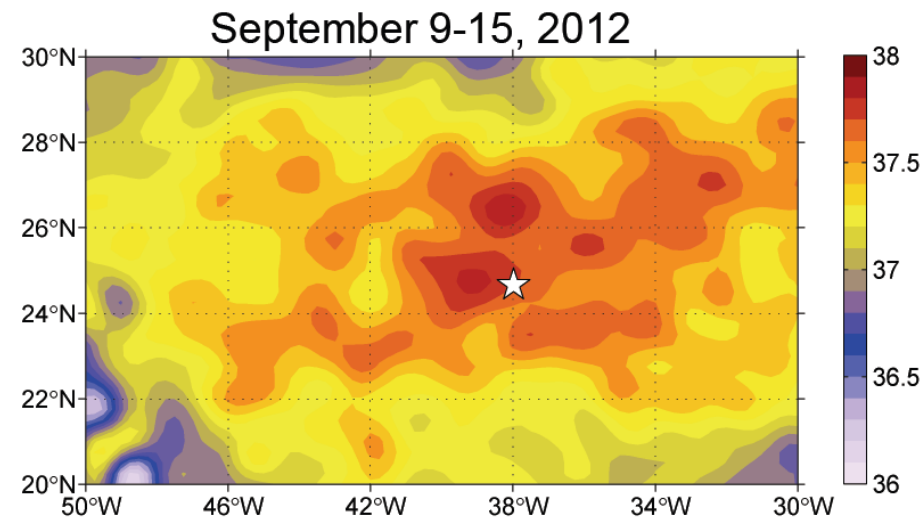
- Salt Flux: $F_S = (E - P) * S$
- Balance:

$$\int F_S dA_S = \int K_V S_Z dA_B + \int K_H \nabla^2 S dA_W$$

Estimate K_V from microstructure
measurements from VMP and T-Gliders,
Estimate K_H from SSS drifters and models

First results:

- Average Turbulent diffusivity from ~1000 T-Glider dives at the 37.0 isohaline yields:
 $K_\rho = 6.8 \times 10^{-5} \text{ m}^2/\text{s} \rightarrow \text{salt flux} = 1.05 \text{ PSU-Sv}$
- Vertical mixing accounts for $\sim 1/4$ of the salt flux put in at the surface.
- Requires $K_H \approx 5 \times 10^3 \text{ m}^2 \text{ s}^{-1} \approx 0.1 \text{ ms}^{-1} \times 50 \text{ km}$
 $K_H \approx u' l$ (*velocity scale* \times *length scale*)





Summary: SPURS-1 in the North Atlantic Salinity Maximum

- A well instrumented field program (with 5 cruises) was carried out in the NA Salinity Maximum, providing opportunities for two approaches to budget calculations.
- The moored time series, in combination with Lagrangian measures of the lateral gradients, allows point budgets to be evaluated on ~3 week time scales.
- The isohaline control volume is a promising approach for evaluating the large space and long time-scale balances in this unique oceanic closed control volume.
- Much analysis remains to be done!